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RESULTS OF THE STUDY OF THE NATURAL RADIOACTIVITY OF THE AIR

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From the Chair of General Hygiene of the First Order of Lenin Medical Institute imeni I. M. Sechenov.

The natural radioactivity of the air is basically determined through its content of radon and the products of its disintegration -- RaA, RaB, RaC, and RaC^1. The latter form aerosols in the air and can be collected on the filter by passing the examined air through it.

In our study 250 to 1,000 l of air were passed, by means of an oil pump of maximum discharge of 50 l (liters) per minute, with a rate of 20 to 25 l/m, through a membranous filter No. 4 of 15 mm diameter fastened in a Zeitz filter-container. The rate of filtration was determined by a reometer.

The filter activity was determined through the total alpha- and beta- activity of radon disintegration products precipitated on the filter by means of a surface counter of the BFL mark with a mica window 1.8 mg/cm^2 thick and of 20 mm diameter. The surface counters of BFL type record in the Geiger range the alpha- as well as beta-radiations of the investigated preparations. The calculation of the activity of the filters was always carried out under standard conditions in lead shielding situated 0.5 cm from the counter window according to the scheme of three-minute count within one minute after the end of filtration.

The effectiveness of recording alpha- and beta- radiations under given geometric conditions was ascertained by measuring under the same conditions the standard of azoacid uranyl with a known figure of activity, and constituted about 15 percent of the total activity of the investigated preparation.

Our experiments showed that the degree of penetration of natural radioactive aerosols through membranous filters

constitutes less than 0.01 percent. With this in view, two filters were placed into the case of the filter-container and, after taking an air sample, the activity of both filters was calculated simultaneously on two devices. In all experiments the activity of the second filter did not exceed the range of the counter.

We also studied the distribution of activity, according to the thickness of filter No. 4. For this purpose, using a scintillation P-349-2 adjustment, we first counted the alpha-activity of the rear part of the filter, and, then, the front part which had been screened with one layer of a pure membranous layer of the same No. 4 filter. After that, we again measured the activity of the rear part of the investigated filter, in order to calculate the disintegration of the active substance on the filter at the time of the second measurement. It turned out that the figure of measured activity in the first case was identical with the second. This fact shows that radioactive aerosols are accumulated predominantly in the frontal layer of the filter of several micron thickness. In this connection, a correction is not needed for self-absorbtion and self-diffusion of beta-particles in the body of the filter. A similar regularity of distribution of the active substance in the filter body is characteristic also of the membranous No. 5 filters.

Membranous No. 5 filters are more suitable for this work because the filtration rate of the tested air, passing through them, reaches 55 to 60 l/m at a 30 mm diameter of the filtrating surface; and the blast engine of the experimental shops imeni Gubkin is used as a suction apparatus. Among the No. 5 membranous filters, certain specimens may show distribution of activity, according to the thickness of the filter, as fairly uniform.

The advantage of filters of the FPP brand is that they possess low resistance and, therefore, ensure a sufficiently high rate of filtration with comparatively low figures of rarefaction created by the suction device. This permits the employment of a regular vacuum cleaner for the filtration of the air.

The method of measuring and computing when determining the activity of the disintegration products of radon -- RaA, RaB, RaC, and RaC^1 -- each one separately, takes up much time. In determining the total alpha- and beta-activity of disintegration products of radon, one can with a certain degree of definiteness state that we are dealing with a radioactive isotope having a half-life of 30 to 40 minutes. This is determined experimentally according to the curves of disintegration of the total activity of radon disintegration products on the filter. The disintegration

of the active substance during the period of preparation of the filter for the count need not be considered, because this period in our experiments occupied only one minute.

The computation of the initial activity, taking into consideration the disintegration during the period of filtration, is carried out according to the following formula:

$$Q = \frac{A \cdot 10^{12} \cdot \lambda}{2{,}2 \cdot K \cdot V(1 - e^{-\lambda t})},$$

where Q -- total alpha- and beta-activity of radon disintegration products (in c/l of air); A -- filter activity during the moment of measuring (in imp/min); K -- correction coefficient on the effectiveness of radiation recording (in percentages); V -- rate of filtration (in l/min); t -- duration of filtration (in minutes); lambda -- the disintegration constant.

At $T_{\frac{1}{2}}$ (half-life) = 35 minutes, lamda = 0.0198 min^{-1}.

As an experiment, we investigated air radioactivity by this method in the area of the clinic of the First Moscow Order of Lenin Medical Institute imeni I. M. Sechenov. Samples of the outside air were taken from the window of the laboratory-room of the semi-cellar and on the third floor level from the window of the physics laboratory of the Chair of General Hygiene.

Air samples were also taken inside the hygienic department of the institute: in the rooms of the physics laboratory of the Chair of General Hygiene located on the third floor, in the hall, and in the laboratory room of the semi-cellar. A total of 84 air samples were examined, in all of them the presence of natural radioactive aerosols was established. The activity of the filter in all samples exceeded the range of the surface tube two- to 20-fold, depending on the place and the time the sample was taken.

The figure of air radioactivity, according to our studies, fluctuates from day to day outside the rooms as well as inside (Table 1).

The air radioactivity on the premises of the physics laboratory exceeds four to six times the radioactivity of the atmospheric air, and the air radio-

Table 1

Fluctuations of natural air-radioactivity outside and within the rooms (activity in 10^{-12} C/liters)

Place where sample was taken	Date	Activity
Physics laboratory (Hygiene building, third floor) 7 December 1954.	18/X 1954 r.	0,8
	23/X 1954 »	0,9
	23/X 1954 »	2,5
	28/X 1954 »	1,9
	30/X 1954 »	2,1
	1/XI 1954 »	0,5
	2/XI 1954 »	0,7
	4/XI 1954 »	1,8
	7/XII 1954 »	2,0
	3/I 1955 »	0,7
Passage of the semicellar (Hygiene building)	7/XII 1954 r.	10,0
	29/XI 1955 »	4,3
	2/XII 1955 »	3,2
	7/XII 1955 »	2,1
	9/XII 1955 »	4,6
	27/XII 1955 »	3,1
	10/I 1956 »	4,6
	17/I 1956 »	3,9
Outside air, at one meter level from the ground	25/XI 1955 r.	0,24
	29/XI 1955 »	0,17
	2/XII 1955 »	0,23
	7/XII 1955 »	0,1
	9/XII 1955 »	0,6
	27/XII 1955 »	0,3
	17/I 1956 »	0,4
	24/XII 1956 »	0,2
	29/XII 1956 »	0,3
	2/I 1957 »	0,3

activity in the semicellar passage exceeds 8 to 25 times the natural radioactivity of the outside air when samples were taken simultaneously. These correlations also vary from day to day. Taken as an average of seven tests, the air radioactivity in the semicellar passage exceeded by 14 times the activity of the atmospheric air (Table 2). Ventilation of the building considerably reduced the air radioactivity. For example, air radioactivity in the semicellar laboratory, prior to ventilation, was $3.6 \cdot 10^{-12}$ C/l; after ventilation it was $1.6 \cdot 10^{-12}$ C/l. The radioactivity of the atmospheric air was $0.24 \cdot 10^{-12}$ C/l in a simultaneous test.

The natural radioactivity of the atmospheric air in December 1954-1957 was almost the same: $0.4 \cdot 10^{-12}$ C/l in December 1954, $0.3 \cdot 10^{-12}$ C/l in December 1955, $0.2 \cdot 10^{-12}$ C/l in December 1956, and $0.36 \cdot 10^{-12}$ in December 1957 (on the average of three measurements taken during December of each year).

The data on air radioactivity in buildings, obtained by us with disintegration products of radon, are close to the figures of air radioactivity on radon cited by R. M. Sievert. According to his data, the air radioactivity in brick buildings varies between 0.3 to $1.2 \cdot 10^{-12}$ C/l in 54 percent of cases.

According to our data, based on 35 tests, the mean activity of the air in the physics laboratory building during March, October, and November 1954 was $1.4 \cdot 10^{-12}$ C/l and fluctuated within the limits of 0.7 to $2.5 \cdot 10^{-12}$ C/l. The air radioactivity in the semicellar passage was $4.6 \cdot 10^{-12}$ C/l, and of the outside air -- $0.3 \cdot 10^{-12}$ C/l. The natural air radioactivity in the semicellar in one case slightly exceeded the liminal admissible concentration of radon and its disintegration products ($11 \cdot 10^{-12}$ C/l).

Table 2

Natural radioactivity of air within and outside a building during simultaneous sampling

	Activity (in 10^{-12} C/l)							
	1	2	3	4	5	6	7	
Place of sampling	29/XI 1955	2/XII 1955	7/XII 1955	9/XII 1955	27/XII 1955	17/XII 1956	7/XII 1954	average
Atmosphere (from the semicellar window)	0.17	0.23	0.1	0.6	0.3	0.4	0.5	0.33
Semicellar hallway	4.3	3.2	2.1	4.6	3.1	3.9	11	4.6
Ratio of activity in the hallway to the activity in the atmosphere	25	14	21	7.7	10	9.7	22	14

Conclusions

1. The natural radioactivity of the outside air fluctuates constantly (according to our data, between $1 \cdot 10^{-13}$ to $6 \cdot 10^{-13}$ C/l).

2. The natural radioactivity of the air within the buildings exceeds the radioactivity of the outside air four to six times, and in the cellar quarters -- eight to 25 times.

3. The method which we employed is simple and inexpensive, but it permits only approximate figures of the total alpha- and beta-activity of the radon disintegration products in the air.

Submitted 16 July 1957

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